Disease Reduction Goals

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Widespread vaccination of children has resulted in dramatic decreases in morbidity and mortality due to vaccine-preventable diseases in the United States.[1] For example, early in this century before the introduction and widespread use of diphtheria toxoid, diphtheria was a major cause of death of children. In the 1950s, epidemics of polio occurred in the United States; during the period 1951--1954 an average of 16,316 paralytic polio cases and 1876 deaths from polio were reported each year. Likewise, until the incidence of rubella was greatly reduced by the widespread use of rubella vaccine, congenital rubella syndrome (CRS) was a major cause of deafness, mental retardation, and other birth defects in this country. A major rubella pandemic occurred in 1964--1965, resulting in an estimated 20,000 cases of CRS in the United States. As recently as the mid-1980s, before the availability and use of vaccines for the prevention of *Haemophilus influenzae* type b invasive disease (Hib), Hib was the most frequent cause of bacterial meningitis among children and resulted in approximately 900 deaths each year. With vaccination coverage among pre-school-age children now at record high levels, most childhood vaccine-preventable diseases are at all-time low levels (Table 1).

Disease Reduction Goals for 2000 and 2010

In 1993, the Childhood Immunization Initiative (CII) established disease elimination goals for measles, rubella, polio, diphtheria, tetanus (children <15 years of age) and *Haemophilus influenzae* type b invasive disease (children <5 years of age) and a disease reduction goal for mumps.[2] These goals were largely met.[3] The CII goals were interim goals, designed to consolidate gains toward meeting the year 2000 objectives of Healthy People 2000 established in 1991. Healthy People 2000 included disease elimination objectives for diphtheria and tetanus (among persons $\leq$ 25 years of age), polio, measles, rubella, and CRS, and disease reduction goals for mumps, pertussis, and hepatitis B (Table 2).[4] Although no specific disease reduction or elimination goal for Hib was established, there is a goal for the reduction of bacterial meningitis to no more than 4.7 cases per 100,000 people, from a baseline of 6.3 per 100,000 in 1986.

Even more ambitious targets have been proposed for the year 2010. Proposed objectives for 2010 include elimination of indigenous cases of measles, mumps, rubella, and CRS; Hib (among children <5 years of age); tetanus and diphtheria (among persons <35 years of age); and hepatitis B (among persons <25 years of age). In addition, disease reduction goals have been proposed for pertussis (2,000 cases among children <7 years of age) and varicella (400,000 cases).[5] Although these objectives have not yet been finalized, the draft objectives highlight the need for sustained effort and continued improvement in disease control efforts beyond the year 2000, including a focus on reduction or elimination of vaccine-preventable diseases not included in the year 2000 goals.

Progress Toward Disease Reduction Goals

As the year 2000 approaches, several of the year 2000 goals have already been reached. No indigenously-acquired cases of paralytic disease due to wild-type poliovirus have been reported in the United States since 1979. Interruption of indigenous transmission of measles in the United States is well documented by both epidemiologic and laboratory data,[6, 7] and sporadic cases of rubella are detected so infrequently that ongoing endemic transmission of rubella is unlikely to be occurring.[8] This is in contrast to the period 1989-1991, when more than 50,000 cases of measles and almost 3,000 cases of rubella were reported in the United States. With increasing implementation of recommendations for 2 doses of measles-mumps-rubella vaccine (MMR), reported cases of mumps have steadily declined. By the mid-1990s, seasonality of reported mumps cases was markedly reduced, suggesting that ongoing indigenous transmission of mumps may have been interrupted as well.[9]

In order to maintain elimination of indigenous transmission of these diseases, disease control measures in addition to childhood vaccination programs are required. Susceptible young adults should be vaccinated and school-aged children should receive a second dose of measles-mumps-rubella vaccine. Some populations that object to vaccination on religious or philosophic grounds continue to remain susceptible and outbreaks will occur unless the risk of exposure to disease is minimized by high vaccination levels in surrounding populations and better control abroad. Frequent importations of measles and rubella will require better control of these diseases in other countries to reduce the risks for exposure among the remaining susceptible persons in the United States. The occurrence of rubella outbreaks among adults who were not born in this country remains a major challenge to meeting our rubella elimination goal.[8] However, use of mumps vaccine in other countries has been limited by cost of the vaccine, adverse reactions following administration of the Urabe strain (a vaccine not used in the United States), and the limited health burden presented by mumps relative to other vaccine-preventable diseases. Importations of mumps into the United States are now increasingly being reported, and will continue unabated until mumps vaccine is used much more widely in other countries.

During the period 1989--1997 there was a 99% decrease in the incidence of invasive Hib disease among children aged < 5 years.[10] However, in spite of this dramatic reduction, cases of *H. influenzae* type b invasive disease continue to occur among children who are too young to be fully protected with current vaccines and schedules, among children who are not vaccinated on time, and among children who are not fully protected by the existing vaccines. Reservoirs of infection may exist that are not eliminated by current vaccines and strategies; further research is needed to better understand these reservoirs and to devise more effective strategies. Likewise, circulation of diphtheria persists despite very high levels of vaccination.[11] Additional research is needed to better understand the factors that allow indigenous foci of transmission to persist and to refine our control strategies.

Although tetanus cases are now at record low levels, cases continue to occur among children, adolescents and young adults, and during the 1990s two cases of neonatal tetanus — including one in an infant born to a U.S.-born mother — were reported as well.[12, 13, 14] During the 1990s cases among children 1-14 years of age have been reported almost exclusively among children who had received no vaccines because their parents had religious or philosophical objections to vaccination. In addition, in recent years reported cases have increased among young adults, many of whom have a history of intravenous drug use.[12] Preventing tetanus among these populations remains extremely difficult. Tetanus is not a communicable disease, and the causative organism is ubiquitous in the environment; unlike other vaccine-preventable diseases, there is no herd immunity for tetanus. As long as anyone remains susceptible, cases of tetanus can continue to occur in this country.

Although most vaccine-preventable diseases are now at record low levels, pertussis is an exception, with a general upward trend in reported cases since 1980. Reported cases of pertussis have increased among all age groups, but the most dramatic increases have been among school-age children, adolescents, and adults. The reasons for these increases are not completely understood, but are most likely due to increased ascertainment and reporting of pertussis in these age groups in selected states rather than a true increase in incidence.[15] Vaccination coverage among pre-school-age children is high, and children in this age group continue to be well protected by pertussis vaccination, which remains highly effective.[16] In 1997, 95% of children 19-35 months of age had received 3 or more doses of diphtheria and tetanus toxoids and pertussis vaccine *, and only 81% had received 4 or more doses.[17] Meeting the proposed year 2010 objective will require higher coverage and more timely vaccination of children <7 years of age. It is unclear whether new strategies, such as routine vaccination of adolescents with acellular pertussis vaccine, would result in additional decreases in pertussis among young children.

Reported cases of hepatitis B have decreased more than 2-fold since 1990, when 21,102 cases were reported; in 1998 a provisional total of 9,012 cases were reported in the United States. Of these, 1,713 cases (19%) were provisionally reported among persons <25 years of age. Routine vaccination of infants has been recommended since 1991 and catch-up vaccination of all children 11-12 years of age who had not previously received hepatitis B vaccine was recommended in 1995. However, coverage with *hepatitis B vaccine among pre-school-age children has lagged behind that of most other routinely recommended vaccines; in 1997, only 84% of children 19-35 months of age had received a complete series of 3 or more doses of hepatitis B vaccine.[17] Implementation of recommendations for vaccination of adolescents have lagged as well. Because the risk of infection with hepatitis B vaccine is highest among

*This estimate includes those children who received diphtheria and tetanus toxoids (DT) as well. In 1997 this is estimated at no more than 1% of any of the 4 doses.

young adults,[18] catch-up immunization of current adolescents is essential if hepatitis B incidence is to be substantially reduced by the year 2010. In addition, cases continue to occur among young children, in spite of current recommendations for prevention of perinatal infection and for routine vaccination of infants; in 1998, a provisional total of 140 cases were reported among children <10 years of age. The factors that have allowed these cases to continue to occur — programmatic failure to vaccinate all children, or failure of current vaccines or schedules to confer complete protection — need to be better understood.

Varicella vaccine was licensed in the United States in 1995 and in 1996 the ACIP recommended it for routine use among children 12-18 months of age and susceptible older children and adults. Varicella vaccine coverage has lagged behind other childhood vaccines; in 1997 only 26% of children 19-35 months of age had received at least one dose of varicella vaccine.[17] Nonetheless, coverage has increased steadily and will likely exceed 50% nationally by the 4th quarter of 1999. Although varicella is not a nationally notifiable disease and timely national estimates of varicella incidence are not available, adequate surveillance to document impact of disease exists in Michigan, West Virginia, and three active surveillance sites.[19] In all these areas, there were dramatic reductions in reported cases of varicella in the 1998--1999 season, consistent with significant decreases in varicella incidence due to increasing vaccine coverage. With varicella vaccine coverage now rising steadily, the proposed disease reduction objective for 2010 is within reach. Nonetheless, if coverage does not increased rapidly and catch-up immunization of susceptible older children is not implemented, the potential exists for outbreaks among older children, adolescents, and young adults. Another challenge is availability of data to document varicella disease reduction, in the absence of national surveillance (see below).

Surveillance and Disease Reduction Goals

Surveillance is a critical component of national disease reduction and elimination efforts. First, we rely on surveillance data to monitor our progress toward these goals. Most disease reduction goals were established using baseline data from the National Notifiable Diseases Surveillance System, which includes case reports from the routine reporting systems in the 50 states, the District of Columbia, and New York City. These data have been useful for monitoring trends, but are not complete; the completeness of reporting varies by disease (see Chapter 20). Major changes in ascertainment or reporting, resulting in changes in the completeness of reporting, could produce aberrant trend data, but in practice, this has not proven a major problem.

However, data sources do not exist for all vaccine-preventable diseases for which disease reduction goals have been established. Estimates of the number of varicella cases occurring annually have been derived from the National Health Interview Survey, and through the mid-1990s these estimates approximated the annual birth cohort, consistent with our understanding of the epidemiology of varicella.[20] The proposed disease reduction target for 2010 represents a 90% decrease in cases of disease, assuming complete reporting.

No system currently exists to monitor progress toward this objective in a timely way.

There are special challenges for those diseases for which elimination goals have been established. For these diseases, surveillance systems need to not only provide high quality information on the small number of cases that continue to occur (see below), but also must provide evidence that the absence of reported cases is due to absence of disease, rather than the absence of appropriate ascertainment, evaluation, and reporting. For these diseases, development of appropriate surveillance indicators is critical (see Chapter 15).

As vaccination and other disease control efforts reduce disease incidence in the United States, the quality of surveillance data begin to limit the precision with which progress toward disease elimination can be monitored; data quality has become a major limitation. Appropriate laboratory testing must be done to rule out non-cases and confirm the diagnosis for true cases. Although results of serotyping are now reported for an increasing proportion of isolates from invasive cases of *Haemophilus influenzae* type b among children < 5 years of age, the continued lack of this information from some cases limits our ability to track progress toward meeting disease elimination objectives. With high vaccine coverage, mumps can no longer be diagnosed clinically but requires laboratory confirmation.[21, 22]

As disease incidence falls, collecting and reporting complete and accurate information on the remaining cases become increasingly important in order to better understand the factors that allow disease transmission to continue, in spite of high vaccination coverage. The occurrence of vaccine-preventable diseases in a community is a sentinel event that may signal the presence of an un- or underimmunized population within the community, susceptibility among persons not targeted for vaccination by current policies, circulation of an organism against which the vaccine does not confer protection, use of subpotent vaccine, or other factors. Developing an appropriate public health response to the occurrence of such cases requires thorough case investigation, appropriate laboratory testing, and complete and accurate vaccination histories.

The need for public health response is not limited to those diseases targeted for elimination. Antimicrobial therapy can limit the spread of *Bordetella pertussis*, and varicella vaccine is now recommended for use post-exposure. Public health action can limit the spread of these and other vaccine-preventable diseases. Surveillance remains a critical first step in disease prevention and control.

Remaining Challenges

Great challenges remain to meeting the disease reduction and elimination objectives established by Healthy People 2000 and proposed for the year 2010. Meeting these targets will require achieving and maintaining high vaccination coverage among children; improving vaccination coverage among adults; developing effective strategies to reach populations rejecting immunization for religious or philosophical reasons; improving control of vaccine-preventable diseases globally, thereby reducing the frequency of importation; prompt

reporting and thorough case investigations of suspected cases; and rapidly instituting effective disease control measures to limit the spread of disease.

The need to prevent and control the transmission of vaccine-preventable diseases into the next century will require continuous efforts. The 1996 disease reduction and elimination goals presented an opportunity to highlight remarkable progress toward a healthier population in this country, and we are well on our way to meeting many of the year 2000 goals. However, the current record low incidence of many vaccine-preventable diseases provides no grounds for complacency. Coverage has lagged for several vaccines which were more recently recommended for routine use in children, such as hepatitis B and varicella vaccine, and licensure of other vaccines is likely. Assuring high coverage with all recommended vaccines and documenting their impact remains a key challenge of immunization programs now and for the future. ❖

Table 1. Reported cases of selected vaccine-preventable diseases, 1990-1998*

Disease	1990	1991	1992	1993	1994	1995	1996	1997	1998*
Measles	27,786	9,643	2,237	312	963	309	508	138	89
Rubella	1,125	1,401	160	192	227	128	238	181	345
Congenital rubella syndrome	11	47	11	5	7	6	4	5	6
Poliomyelitis, paralytic+	6	10	6	4	8	6	5	3	1
Diphtheria	4	5	4	—	2	—	2	4	1
Tetanus	64	57	45	48	51	41	36	50	34
Haemophilus influenzae invasive disease (aged <5 yrs	nn	1,540¶	592¶	435¶	284‡	193‡	143‡	139‡	150‡
Pertussis	4,570	2,719	4,083	6,586	4,617	5,137	7,796	6,564	6,279
Mumps	5,292	4,264	2,572	1,692	1,537	906	751	683	606
Hepatitis B	21,102	18,003	16,126	13,361	12,517	10,805	10,637	10,416	8,651

* 1998 data are provisional.
\+ No cases were wild virus associated. Data from previous years subject to change due to delayed reporting.
nn not nationally notifiable
¶ Invasive disease including type b, other types, untyped, and untypable strains; only cases due to type b are preventable by vaccination.
‡ Includes type b and unknown serotype.

Table 2. Disease reduction and elimination goals: 2000 and 2010

Disease	2000 Goals	2010 Goals
Congenital rubella syndrome	no goal established	0*
Diphtheria	0†	0+
Haemophilus influenzae type b invasive disease	no goal established‡	0
Hepatitis B	40 per 100,000 population	0¶
Measles	0	0
Mumps	500	0
Pertussis	1,000	2,000§
Polio (wild-type virus)	0	0**
Rubella	0	0
Tetanus	0†	0+
Varicella	no goal established	400,000

* Source: National Congenital Rubella Syndrome Registry.

† Among persons $\leq$ 25 years of age.

\+ Among persons < 35 years of age.

‡ Although no goal was established specifically for Hib, Objective 20.7 sets a goal for reduction in the incidence of bacterial meningitis from 6.3 per 100,000 population (1986) to no more than 4.7 per 100,000 by the year 2000.

¶ Among persons < 25 years of age.

§ Among children <7 years of age.

** Polio expected to be eradicated by the year 2000.

References

1. CDC. Impact of vaccines universally recommended for children — United States, 1900-1998. MMWR 1999;48:243-8.

2. CDC. Reported vaccine-preventable diseases — United States, 1993, and the Childhood Immunization Initiative. MMWR 1994;43:57-60.

3. CDC. Status report on the Childhood Immunization Initiative: Reported cases of selected vaccine-preventable diseases — United States, 1996. MMWR 1997;46:665-71.

4. Department of Health and Human Services. Healthy People 2000: National Health Promotion and Disease Prevention Objectives. U.S. Department of Health and Human Services: Washington, D.C., 1991; DHHS publication no. PHS-91-50213.

5. U.S. Department of Health and Human Services. Healthy People 2010 Objectives: Draft for Public Comment. U.S. Department of Health and Human Services: Washington, D.C., 1998.

6. Rota JS, Heath JL, Rota RA, et al. Molecular epidemiology of measles virus: identification of pathways of transmission and implications for measles elimination. J Infect Dis 1996;173:32-7.

7. CDC. Measles — United States, 1997. MMWR 1998;47:273-6.

8. CDC. Rubella and congenital rubella syndrome -- United States, 1994-1997. MMWR 1997;46:350-4.

9. Plotkin SA, Wharton M. Mumps vaccine. In: Vaccines (Third Edition) edited by SA Plotkin and WA Orenstein. WB Saunders Co., 1999, pp.267-92.

10. CDC. Progress toward eliminating *Haemophilus influenzae* type b disease among infants and children — United States, 1987-1997. MMWR 1998;47:993-8.

11. CDC. Toxigenic *Corynebacterium diphtheriae* -- Northern Plains Indian community, August - October 1996. MMWR 1997;46:506-10.

12. Bardenheier B, Prevots DR, Khetsuriani N, Wharton M. Tetanus surveillance — United States, 1995-1997. MMWR 1998;47(SS-2):1-13.

13. Craig AS, Reed GW, Mohon RT, et al. Neonatal tetanus in the United States: a sentinel event in the foreign-born. Pediatr Infect Dis J 1997;16:955-9.

14. CDC. Neonatal tetanus — Montana, 1998. MMWR 1998;47:928-30.

15. Güriş D, Strebel PM, Bardenheier B, et al. Changing epidemiology of pertussis in the United States: increasing reported incidence among adolescents and adults, 1990--1996. Clin Infect Dis 1999;28:1230-37.

16. Güriş D, Strebel PM, Tachdjian R, et al. Effectiveness of the pertussis vaccination program as determined by use of the screening method: United States, 1992--1994. J Infect Dis 1997;176:456-63.

17. CDC. National, state, and urban area vaccination coverage levels among children aged 19--35 months — United States, 1997. MMWR 1998;47:547-54.

18. Coleman PJ, McQuillan GM, Moyer LA, et al. Incidence of hepatitis B virus infection in the United States, 1976--1994: estimates from the National Health and Nutrition Examination Surveys. J Infect Dis 1998;178:954-9.

19. CDC. Evaluation of varicella reporting to the National Notifiable Disease Surveillance System — United States, 1972--1997. MMWR 1999;48:55-8.

20. Wharton M. The epidemiology of varicella-zoster virus infections. Infect Dis Clin N Am 1996;10:571-81.

21. Gaulin C, DeSerres G. Need for a specific definition of mumps in a highly immunized population. Can Commun Dis Rep 1997;23:14-6.

22. Pelosi JW, Besselink LC. Reducing mumps morbidity in Texas. Abstracts of the 30th National Immunization Conference. Washington, DC, April 9-12, 1996.